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DETERMINATION OF MECHANICAL AND DURABILITY PROPERTIES OF ULTRAFINE SLUDGE CONCRETE

Manda Goutam V Sai Manikanta
M.Tech CEM, Civil Engineering Department, SRM University,
Kattankulathur, Chennai, India

P. Krithika
Assistant Professor (O.G), Civil Engineering Department, SRM University,
Kattankulathur, Chennai, India

ABSTRACT

The use of marble in various ways is increasing every year worldwide due to increase in population. Due to increasing usage, there is increase in waste product of marble which creates lot of problem in disposal. And hence as a recycling act of this waste product, a lot of research work has been done in improving the performance of concrete with partial replacement of cement, fine aggregate and coarse aggregate. Ultra fine sludge is obtained as waste product during the process of cutting, polishing of marble in marble industry. This sludge does not possess any binding property but it act as filler material in the concrete. Thus, this material will fill the voids in concrete which in turn increase the density and strength will also be more than the conventional concrete. The normal cement concrete of M40 grade was taken into account and the cement was replaced with ultra fine sludge in different ratios of 5%, 10% and 15%. The properties like compressive, split tensile, flexural strength and durability properties were determined in this paper. 5% of ultra fine sludge is optimum replacement for the mechanical properties.

Key words: Ultra fine sludge concrete, Cement, Marble waste, Compression, Split tensile, Flexural.

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1. INTRODUCTION

In present scenario, concrete technology is varying and developing. So cement scarcity is becoming more and at the same time pollution is created from the cement industries. In the same way marble usage is also more and marble waste is creating pollution. Presently large amount of marble waste is produced from the marble industry. This waste may create

environmental problems. So this marble waste is used in concrete by partial replacement of cement by this we can reduce environmental problems and scarcity also.

Actually marble is a metamorphic rock resulting from the transformation of pure lime stone [1]. Marble powder is used in cement industry upto 75 microns size particles [5] and marble slurry is also used in roads for making pavement layers in embankments [6]. This marble slurry is used in concrete replacing fine aggregate[7] and it is not only used as aggregate it is also as curing aid, due to this long term curing is done for concrete[8].In the same way diatomite and waste marble powder is partial replaced in cement[9].

Marble is available in the form of rocks, this rocks is converted into proper shape and size for the usage and based on requirement, for this purpose in industries they did some process like cutting, polishing is done by jaw crushers and sawing equipments. While doing this process some waste will be liberated from the industry, here water is used in industry for processing and this waste is in the form of slurry. So this waste is showing more impact on environment and humans. This slurry is dried and then takes the solid waste, which available in the form of powder [10]. Then collect this powder and used for the replacement of cement in the concrete. This marble is used as filler material it won't have any bonding property, it just fill the voids in the concrete and gives the strength.

In this project, the size of marble particle 44 microns is used, to decrease the voids in the concrete then automatically the strength may increase. This project describes the feasibility of using marble sludge dust in concrete by partial replacing of cement. By finding the mechanical (Compression, Split tensile and Flexural Strength) properties and durability properties (by using sulphuric acid for curing) of concrete [11].

1.1. Objectives of the Study

To arrive at the optimum percentage of ultra fine sludge for replacing cement and determine the mechanical behaviour and durability of ultra fine sludge concrete.

1.2. Scope of the Project

- By replacing cement with ultra fine sludge, cost of structure can be reduced by giving sustainable environment without degrading the strength of concrete.
- Use of ultra fine sludge which is already a waste material helps to reduce landfills and hence green concrete is obtained.

2. MATERIALS

2.1. Cement

Ordinary Portland cement is the most commonly used cement in the world. This cement is originated from the lime stone. Cement is a fine material produced by heating the materials in kiln to form a clinker, and this clinker is grinded into powder and add small amount of other materials to form cement. For work 53 grade cement is used.

2.2. Fine Aggregate

Naturally formed fine aggregate is used for this project, and it is taken from the available river beds. Aggregate size below 4.75 is taken as fine aggregate. For finding the Zone of sand, sieve analysis is done. And zone II is used for making the mix design of concrete.

2.3. Coarse Aggregate

Coarse aggregate is obtained from the quarries and it is in the form of broken stones. It is having irregular shapes, used aggregate should be retained on 4.75mm sieve. Angular aggregates give good strength to the concrete rather than rounded and flaky aggregates. For this project 20mm size of angular aggregate is used.

2.4. Ultrafine Sludge

Actually marble is available in the form of rocks, which is converted to proper shape and size for the usage and based on requirement. For this purpose in industries processes like cutting, polishing are done. While doing this process some waste will be liberated from the industry, in the form of slurry due the usage of water in the process of making marble. This waste shows more impact on environment and humans also. This slurry is then dried to form a solid waste in the form of sludge. Which is then converted into powder form and this powder is collected and used for the replacement of cement in concrete.

Table 1 Physical properties of ultra fine sludge

Physical State	Fine powder
Odour	Odourless
Appearance	Free flowing (clear particle pure)
Colour	Natural pure white
Specific gravity	2.6
Moisture	Below
Particle size	325 Mesh

Table 2 Chemical properties of ultra fine sludge

Silica	SiO_2	11.38%
Alumina	Al_2O_3	0.23%
Ferric Oxide	Fe_2O_3	0.09%
Titanium Dioxide	TiO_2	NIL
Calcium Oxide	CaO	45.18%
Calcium Carbonate	$CaCO_3$	88.5%
Magnesium Oxide	MgO	0.20%
Magnesium Carbonate	$MgCO_3$	0.42%
Sulphur	SO_3	0.008%
Phosphorus	P_2O_5	0.009%

3. METHODOLOGY

Collection, study and review of various journals related to this ultra fine sludge concrete is done. Required materials are collected for the experimental work. Then preliminary tests are conducted for the cement, fine aggregate and coarse aggregate. Tests like specific gravity of cement, fineness modulus of cement and specific gravity of fine aggregate, sieve analysis for sand. By using all these test result prepared the mix design for M40 grade of concrete. According to IS 10262:2009 mix design is done.

By using M40 mix design prepares a concrete mix and casted the cubes, cylinders and flexural beams by partially replacing cement with ultra fine sludge. The casted specimens are

tested for 7, 14 and 28 days. For durability properties, acid resistance method is used. For this method 2% concentrated sulphuric acid (H_2SO_4) is used for curing upto 60 days.

4. RESULTS

4.1. Compressive Strength

Concrete specimens are done with M40 grade concrete and the size of the specimens is 150×150×150mm. These specimens are made with the replacement of cement with marble waste (Ultra Fine Sludge) partially like 0%, 5%, 10 and 15%. At 5% replacement only more strength is obtained compared to conventional (0% replacement) concrete, for every 7, 14 and 28 days strength is increased from conventional to 5% replacement. At 10% replacement strength is strength is decreased at 28 days, but at the initial days (7 & 14days) strength is increased than the conventional concrete but at the later age (*i.e* 28days) strength is decreased. In 15% replacement at every 7, 14 and 28 days strength is decreased. Compressive strength test results are shown in table 3. Compression test for cube and Comparison of all compressive strength test results is shown in figure 1 & 2.

Table 3 Compressive strength results

Replacement of Ultra Fine Sludge	Compressive strength (N/mm^2)		
	7 Days Strength	14 Days Strength	28 Days Strength
Conventional Concrete	29.8	33.55	42.45
5%	32.96	41.97	49.55
10%	31.49	33.83	35.62
15%	27.94	30.14	32.96

Figure 1 Compression test for cube

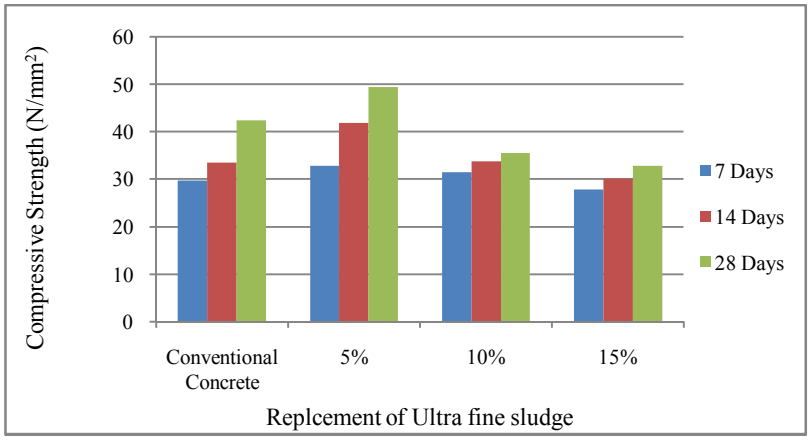

Figure 2 Comparison of all compressive test values

4.2. Split Tensile Strength

Specimens are done with M40 mix proportion at size of 150mm diameter and 300mm long. In the same way Ultra Fine Sludge is replaced in the percentage of 0%, 5%, 10% and 15%, and these specimens are cured for 7, 14 and 28days. At 5% replacement tensile strength is increased at every age (7,14 and 28 days). Tensile strength is decreased completely when compared to conventional at every age. For 15% replacement, tensile strength is completely decreased compare to all percentage of replacement. Split tensile strength test results are show in table 4. Split tensile test for cylinder and comparison of all split tensile strength test values is shown in figure 3 & 4.

Table 4: Split tensile strength results

Replacement of Ultra Fine Sludge	Split tensile strength (N/mm^2)		
	7 Days Strength	14 Days Strength	28 Days Strength
Conventional concrete	2.7	3.02	3.82
5%	3.91	3.21	4.02
10%	2.57	2.73	3.64
15%	2.32	2.52	3.01

Figure 3 Split tensile test for cylinder

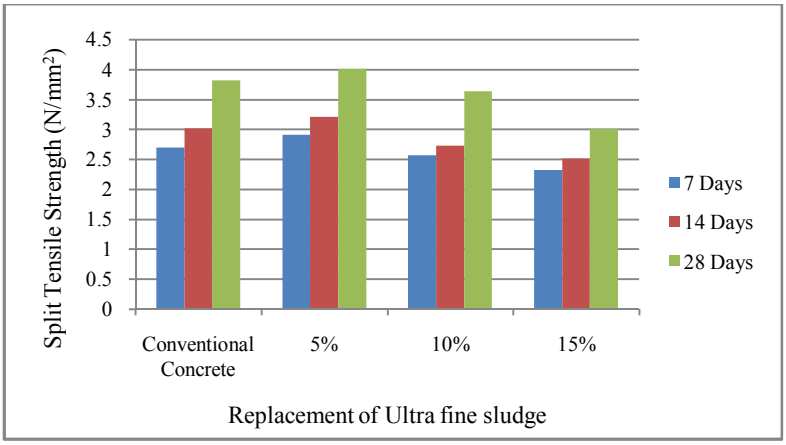

Figure 4 Comparison of all split tensile strength test values

4.3. Flexural Strength

Concrete specimens are done at the size of 500×100×100 mm, it will be look like prism. Replacing of ultra fine sludge and curing is done as above. In flexural strength, the result is different from compressive and split tensile strengths. In above compressive and split tensile test, strength is increased at 5% and decreased at 10%. But in flexural strength, value is

increased upto 10% replacement. At initial 5% replacement value is slightly increased than the conventional concrete, again at 10% replacement strength is increased than the 5% replacement and at 15% replacement strength is decreased when compared to conventional concrete. Flexural strength test results are shown in table 5. Flexural test for beam and comparison of all flexural strength test values is shown in figure 5 & 6.

Table 5 Flexural strength test results

Replacement of Ultra Fine Sludge	Flexural Strength (N/mm^2)		
	7 Days strength	14 Days Strength	28 Days Strength
Conventional concrete	2.6	3.3	4.8
5%	2.8	3.86	5.06
10%	3.4	4.53	5.73
15%	2.53	3.2	4.53

Figure 5 Flexural test for beam

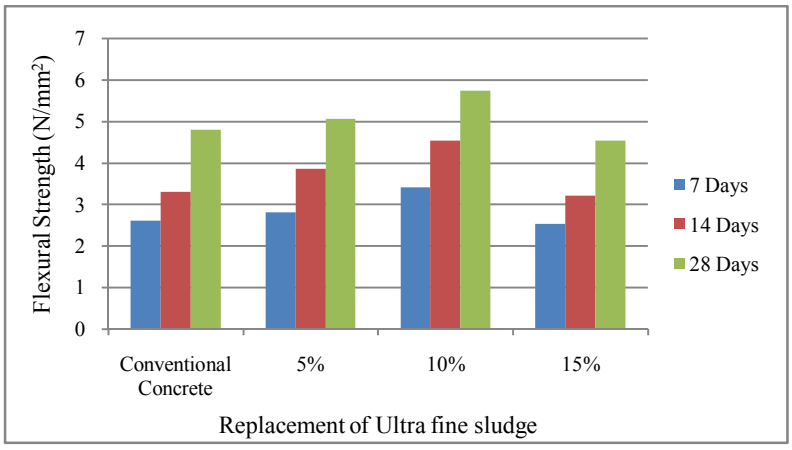

Figure 6 Comparison of all flexural strength test values

4.4. Durability Properties

For durability property, acid resistance is carried out for the specimens. Concrete specimens are made according to the mix design to the size of 150×150×150mm. Replacement of ultra fine sludge is same as replaced in compressive, split tensile and flexural strength tests (0%, 5%, 10% and 15%), but here water curing is done only for 7 days. After 7 days specimens are taken out from the water and dried to the atmosphere for 2days. Later take the dry weight of the specimens, and prepare a solution of sulphuric acid at 2% concentration. Then specimens are placed in 2% concentrated sulphuric acid solution upto 60 days. After 60 days specimen s are taken out from the acid and wash with water. Then specimens dried to the atmosphere for

2 days and take the weight of the specimens. Calculate the weight loss using the collected weights of the specimens (before immersion in acid and after immersion in acid).Percentage of weight loss values are shown in table 6. Cube after acid curing and percentage of weight loss graph is shown in figure 7 & 8.

Table 6 Percentage of weight loss

Replacement of Ultra fine sludge	Weight before Acid Curing	Weight after Acid Curing	Percentage of weight loss
Conventional concrete	8.586	8.386	2.32
5%	8.550	8.296	2.65
10%	8.576	8.2	4.38
15%	8.583	8.056	6.14

Figure 7 Cube after acid curing

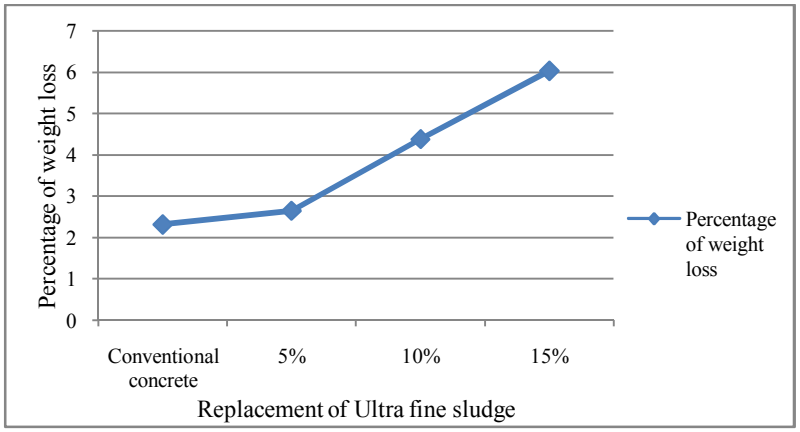

Figure 8 Percentage of weight loss graph

5. CONCLUSION

This work is on concrete by replacing ultra fine sludge with cement partially. By using ultra fine sludge in concrete, results are more effective than normal concrete. Because in concrete micro voids is present after compaction also, by replacing the cement with ultra fine sludge, void will be closed and obtained better result than the conventional concrete. While replacing ultra fine sludge in various proportions, following conclusions have been incurred.

- For compression strength 5% replacement of ultra fine sludge is optimum and fails at 10% replacement.
- In split tensile also 5% replacement is optimum and fails at 10% replacement.

- But in flexural strength it is optimum for 10% replacement of ultra fine sludge.
- For durability properties it is found that the conventional concrete is better performing rather than ultra fine sludge concrete. During replacement, the weight loss and erosion is more in ultra fine sludge concrete.

From the above results, it is concluded that, 5% replacement of ultra fine sludge is optimum. Effective results are obtained in mechanical properties.

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